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PHYSICAL PROPERTIES OF SUGARCANE

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ABSTRACT

Specific weight and specific volume of 9 sugarcane varieties were determined in Agricultural Engineering Workshop of Bangladesh Sugarcane Research Institute (BSRI) at Ishurdi and crushing strength of 6 sugarcane varieties was determined in the Material Testing Laboratory of the Department of Farm Structure, Bangladesh Agricultural University (BAU), Mymensingh. The highest specific weight was 1.1942 g/cc for variety Isd 2/54 and the lowest was 1.0585 g/cc for variety Nagarbari. Consequently the highest specific volume was 0.9447 cc/g for variety Nagarbari and the lowest was 0.8374 cc/g for variety Isd 2/54. The variety Isd 2/54 was found to have longest internodes (111 cm) followed by variety Isd 20 and the shortest internode (83 cm) was found in variety Isd 22. The crushing strength of variety Isd 2/54, Isd 20, Isd 21, Isd 22, L. Jaba-C and Nagarbari were found to have increasing trend from bottom to top while variety Isd 16 showed decreasing trend from bottom to top. The crushing strength of the bottom parts of the stalks of six variety of sugarcane were in the range of 15.5 to 25.5 kg/cm. It was observed that the relation between crushing strength and the diameter of the stalk or its position from the ground level was not statistically significant.

INTRODUCTION

Sugarcane is the second important cash crop of Bangladesh and is the only raw material for white refined sugar and brown unrefined sugar (locally called Gur). The annual average sugarcane production in Bangladesh is about 6.97 million tons (Hossain et. al. 1994). However, only 33% of this sugarcane is used for producing white refined sugar in the 16 sugar mills of the country where large machines are used. On the other hand 45% of the sugarcane is used for producing Gur in the rural area where small machine like country crushers and power crusher are used (Hossain, 1992).

At present about 27 sugarcane varieties have been released from Bangladesh Sugarcane Research Institute, Ishurdi, Pabna. Among them 7 to 8 varieties are cultivated in the mill zone and non-mill zone areas of the country. The widely cultivated varieties are Isd 2/54, L. Jaba-C, Isd 16, Isd 18, Isd 19, Isd 20 and Isd 21. Beside these some local varieties like Nagarbari, Mishrimala, Ghendaria etc. are also being cultivated in the country. Six promising varieties viz. Isd 22, Isd 24, Isd 25, Isd 26, Isd 27 and Isd 28 have been released in recent years but have not been introduced in the farmers' field yet. The cultivated varieties and their coverage in mill zone area during 1992-93 is shown in Table 1.

Physical properties of sugarcane such as specific weight and specific volume are important for designing sugarcane transporting wagons or trailers. Therefore, engineers concerning the design of sugarcane transporting wagon need

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to have profound knowledge about specific weight and specific volume of sugarcane.

The crushing strength of sugarcane , on the other hand, is also an important factor in the design of crusher, specially where energy for crushing is a limiting factor such as in the country crusher. As 45% of the total sugarcane produced in the country is crushed by the country crusher for producing Gur in the rural area, engineers who design these crusher should have good idea about the crushing strength of sugarcane. Crushing strengths of different varieties of sugarcane are required to be considered in designing and selecting crushers to maximize the juice recovery from sugarcane and to minimize the losses.

Considering the importance of the physical properties of sugarcane an experiment was undertaken to determine total length of sugarcane stalk, number and length of internodes, specific weight, specific volume, and crushing strength of some selected varieties of sugarcane. The study was carried out in the year 1994-1995.

Table 1 Cultivated area and the percentage of different varieties of sugarcane in mill zone area in 1992-93.

Variety	Area (ha)	Percentage
Isd 2/54	32456.10	36.74
L. Jaba-C	22935.52	25.96
Isd 16	20579.20	23.29
Isd 18	8037.61	9.10
Isd 19	1047.21	1.80
Isd 20	978.77	1.11
Nagarbari	48.89	0.05
Isd 21	21.06	0.02
Others*	2243.29	2.54

Others include varieties like BS 96, C1158, C 975, BO 34 etc.

MATERIALS AND METHODS

Selection of Varieties

Nine important varieties of sugarcane that are commonly grown in Bangladesh were selected for determination of physical properties. These are Isd 2/54, Isd 16, Isd 18, Isd 19, Isd 20, Isd 21, Isd 22, L. Jaba-C and Nagarbari.

Total Length of Sugarcane stalk, Number of Internodes per stalk and Length and Diameter of Internodes

The number of internodes, length of internodes and total length of nine sugarcane varieties viz. Isd 2/54, Isd 16, Isd 18, Isd 19, Isd 20, Isd 21, Isd 22, L. Jaba-C and Nagarbari, collected from BSRI farm were also measured from bottom to top by steel tape. Six stalks of each variety were taken for measuring length of internodes and average of those six readings were taken as the mean value for the variety. The physical parameters such as diameter, length and weight were measured and number of internodes in each stalk were counted.

Specific Weight and Specific Volume of Sugarcane

Specific weight of sugarcane is the weight per unit volume of sugarcane stalk, expressed as gram per cubic centimeter (g/cc). On the other hand, specific volume of sugarcane is the volume of sugarcane stalk per unit weight of cane stalk and it is expressed as cubic centimeter per gram (cc/g).

Six stalks of each variety were collected from the farm of Bangladesh Sugarcane Research Institute (BSRI), Ishurdi, Pabna and the number of internodes in each stalk were counted. After removing the leaves the length, weight and diameter of each stalk were measured. Each stalk was then cut into30 cm long pieces by sharp knife and a bundle was made. The bundle was immersed in water and the weight of the bundle was taken keeping it into water. The weight of the bundle in air and in water was taken by a balance. The volume of each stalk was then found from the loss of weight in water.

Finally the specific weight and specific volume of each variety was calculated using the following formula :

$$W = \frac{W_1}{W_1 - W_2} \times c \qquad \text{..... (1)}$$

$$V = \frac{W_1 - W_2}{W_1 \times c} \qquad \text{..... (2)}$$

where, W = Specific weight
V = Specific volume
W_1 = Weight of cane in air
W_2 = Weight of cane in water
c = Correction factor for water temperature.

Crushing Strength of Sugarcane

For measuring the crushing strength of sugarcane, six commonly cultivated sugarcane varieties viz. Isd 2/54, Isd 16, Isd 20, Isd 21, L. Jaba-C and Nagarbari with six stalks of each variety were collected from Kaliachapra sugar mill's (KCSM) farm at Kishorgonj during 1994-95. For determining the crushing strength of sugarcane, each stalk was cut into 7 to 10 pieces from the bottom with a carbon steel (300 mm x 12 mm, 24 TPI) hack saw blade such that each portion contained two internodes and three nodes. The length and diameter of each portion was measured using steel tape and a vernier scale. The crushing load for each portion was measured using a Universal Testing Machine (made in Japan) at the Material Testing Laboratory of the Department of Farm Structure, BAU. The maximum load taken by the cane stalk before cracking was its crushing load. Crushing strength of each stalk of each variety was expressed in kg per centimeter of length. The average crushing strength and diameter of six varieties of sugarcane at ground level were also calculated.

RESULTS AND DISCUSSION

Length and Diameter of Stalks

Growth as well as the length and diameter of sugarcane stalks are dependent on time, genetic constitution and environmental factors such as temperature, moisture, radiant energy, soil reactions, supply of mineral nutrients, atmospheric composition and soil gaseous content (Ali, 1993). In Table 2 It can be seen that the average stalk lengths of different varieties of sugarcane vary from 1.84 meters (for Isd 20) to 2.74 meters (for Isd 18) and the average stalk diameters from 1.83 cm (for Isd 22) to 2.01 cm (for Isd 16).

Internodes and Length of Internodes

Total number of internodes of nine varieties of sugarcane together with their average stalk length and the length of internodes at 5 positions are given in Table 2. The highest number of internode (27) was found for varieties Isd 16, Isd 18 & Isd 20. Varieties Isd 21, Isd 22 and L. Jaba-C had got 26 numbers of internodes. The lowest number of internode (22 Nos.) was found for variety Isd 19.

The length of all internodes from bottom to top of nine varieties of sugarcane were studied. The longest internode at bottom (134 cm) was found for variety L.Jaba-C followed by variety Nagarbari (133 cm) while the shortest internode at bottom (77 cm) was found for variety Isd 19; But the average longest internode (111 cm) was for variety Isd 2/54 followed by variety Isd 20 (105 cm) while the average shortest internode (83 cm) was for variety Isd 22 (Table 2). Analysis of the data on length of internodes revealed that the length of the internodes at bottom of the varieties L. Jaba-C, Nagarbari and Isd 20 is larger and showed decreasing trend up to the top of the cane. But the length of the internodes of all other varieties at the bottom is smaller. Only varieties Isd 2/54 and Isd 21 showed sudden increase in length at the middle position.

Specific Weight and Specific Volume of Sugarcane

Specific weight and specific volume of nine sugarcane varieties together with their average length and weight are given in Table 3. The highest specific weight was 1.1942 g/cc for variety Isd 2/54 and the lowest was 1.0585 g/cc for Nagarbari.

Table 2 Number of Internodes per stalk and Length of internodes of different varieties of sugarcane at different positions.

Variety	No. of internodes	Total length of stalk (m)	Length of internode (mm) at different positions of the stalk					
			Bottom	1/4th from bottom	Middle	3/4th from bottom	Top	Average
Isd 2/54	23	2.542	125	105	114	80	75	111
Isd 16	27	2.560	84	116	82	90	50	95
Isd 18	27	2.736	82	141	106	90	62	101
Isd 19	22	1.897	77	119	101	78	35	86
Isd 20	27	2.840	121	120	101	79	70	105
Isd 21	26	2.484	97	103	108	96	50	96
Isd 22	26	2.156	104	107	74	78	40	83
L. Jaba-C	26	2.380	134	109	102	68	40	92
Nagarbari	25	2.495	133	114	111	84	43	100

Table 3 Average length, diameter, weight, specific weight and specific volume of some promising sugarcane varieties.

Variety	Average length of stalks(m)	Average diameter of stalks (cm)	Number of internodes/ stalk	Average weight (kg)	Average Specific weight (g/cc)	Average Specific volume (cc/g)
Isd 2/54	2.542	1.864	23	0.792	1.1942	0.8374
Isd 16	2.560	2.006	27	1.092	1.0813	0.9250
Isd 18	2.736	1.989	27	1.108	1.1170	0.8953
Isd 19	1.897	1.977	22	0.867	1.1436	0.8745
Isd 20	1.840	1.994	27	1.167	1.1158	0.8962
Isd 21	2.484	1.936	26	1.042	1.0728	0.9321
Isd 22	2.156	1.827	26	0.825	1.1421	0.8680
L. Jaba-C	2.380	1.848	26	0.770	1.0952	0.9131
Nagarbari	2.495	1.976	25	0.692	1.0585	0.9447

Consequently the highest specific volume was 0.9447 *cc/g* for Nagarbari and the lowest was 0.8374 *cc/g* for Isd 2/54.

Crushing Strength of Sugarcane

The analysis of average crushing strengths of six sugarcane varieties viz. Isd 2/54, Isd 16, Isd 20, Isd 21, L. Jaba-C and Nagarbari at different positions (along the total length) of the cane from bottom to top showed that the crushing strength of variety Isd 2/54 ranged from 17.05 to 22.27 kg/cm and it increased slowly from bottom to top of the cane. The crushing strength of variety Isd 16 was found to vary from 15.92 to 25.53 kg/cm and it increased gradually from top to bottom. Reverse trend was observed for the variety Isd 20 and was found to vary from 15.51 to 27.31 kg/cm. For variety Isd 21, the crushing strength varied from 17.34 to 22.14 kg/cm and the strength had an increasing trend similar to the variety Isd 2/54. The crushing strength of variety L. Jaba-C was found to vary from 19.81 to 26.28 kg/cm and the strength was lower at the bottom (i.e. at ground level) and higher at the top. That is, the strength gradually increased from bottom to top of the cane stalk. The crushing strength of variety Nagarbari was found to vary from 15.87 to

Table 4 Average crushing load and diameter of six varieties of sugarcane at ground level

Variety	Diameter (cm)			Crushing load (kg/cm)		
	Bottom	Middle	Top	Bottom	Middle	Top
Isd 2/54	1.48	1.5	1.3	17.00	22.27	20.69
Isd 16	1.62	1.4	1.1	25.53	20.41	15.92
Isd 20	1.57	1.3	1.1	15.51	19.85	27.31
Isd 21	1.58	1.3	1.2	17.34	20.83	22.14
L. Jaba-C	1.47	1.4	1.0	19.81	24.55	26.28
Nagarbari	1.73	1.6	1.4	15.87	24.8	27.34

27.34 kg/cm with an increasing trend from bottom to top. It was observed that the crushing strength of 5 varieties (Isd 2/54, Isd 20, Isd 21, L. Jaba-C and Nagarbari) increased gradually from bottom to top while that of the variety Isd 16 decreased gradually from bottom to top. The average crushing strength at three different positions of sugarcane stalks are given in Table 4. There was no correlation ($r = -0.043065$) between cane diameter and crushing strength of sugarcane stalks.

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